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Zhu et al.

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(54) **COMPATIBILITY SCORING OF USERS IN A SOCIAL NETWORK**

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This patent is subject to a terminal disclaimer.

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Related U.S. Application Data

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(51) **Int. Cl.**
G06Q 99/00 (2006.01)

(52) **U.S. Cl.** **705/319**

(58) **Field of Classification Search** ..... None
See application file for complete search history.

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(74) *Attorney, Agent, or Firm* — Baker Botts L.L.P.

(57) **ABSTRACT**

The compatibility score of individuals in a social network is computed based on the compatibility of interests expressed by these individuals. The compatibility score between any two interests is calculated as the log of the estimated probability that a member of the social network will express both interests as his or her interests divided by the product of: (i) the estimated probability that a member of the social network will express the first of the two interests as his or her interest and (ii) the estimated probability that a member of the social network will express the second of the two interests as his or her interest. The compatibility score between two individuals is calculated as the sum of the compatibility scores between each interest appearing in a set of interests expressed by the first of the two individuals and each interest appearing in a set of interests expressed by the second of the two individuals.

20 Claims, 9 Drawing Sheets

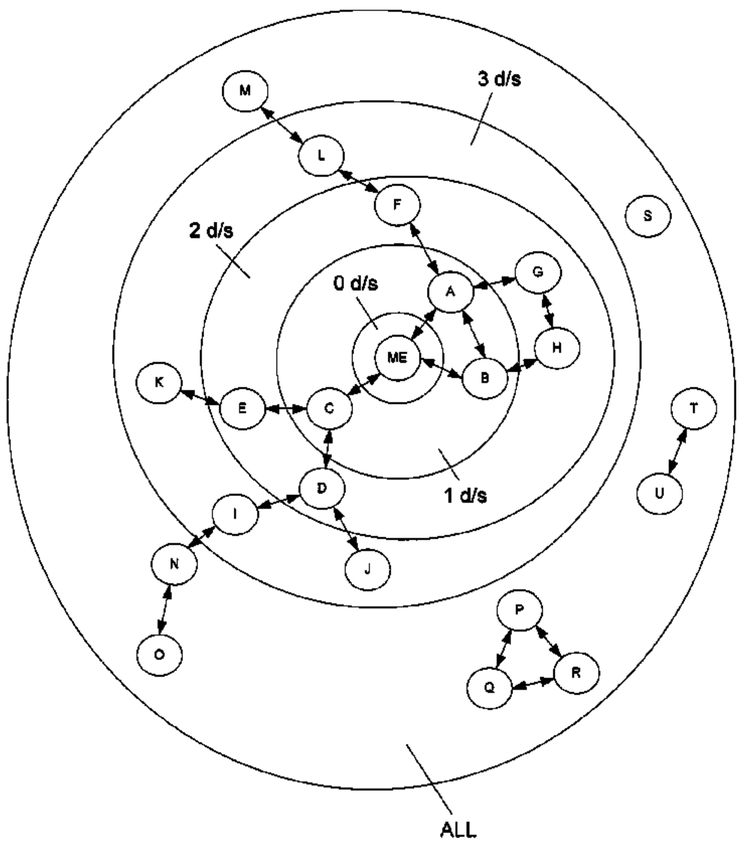


FIG. 1

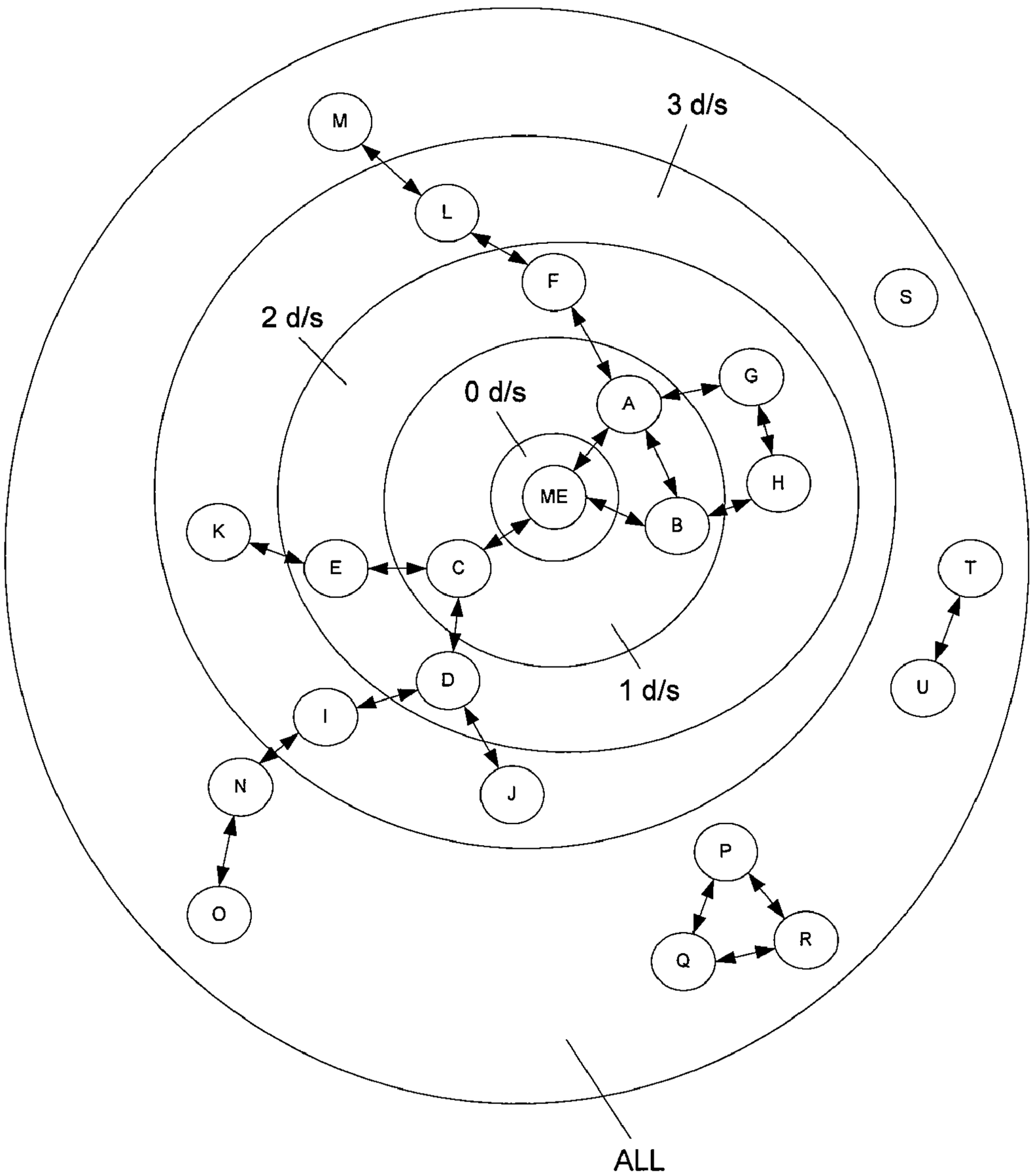


FIG. 2

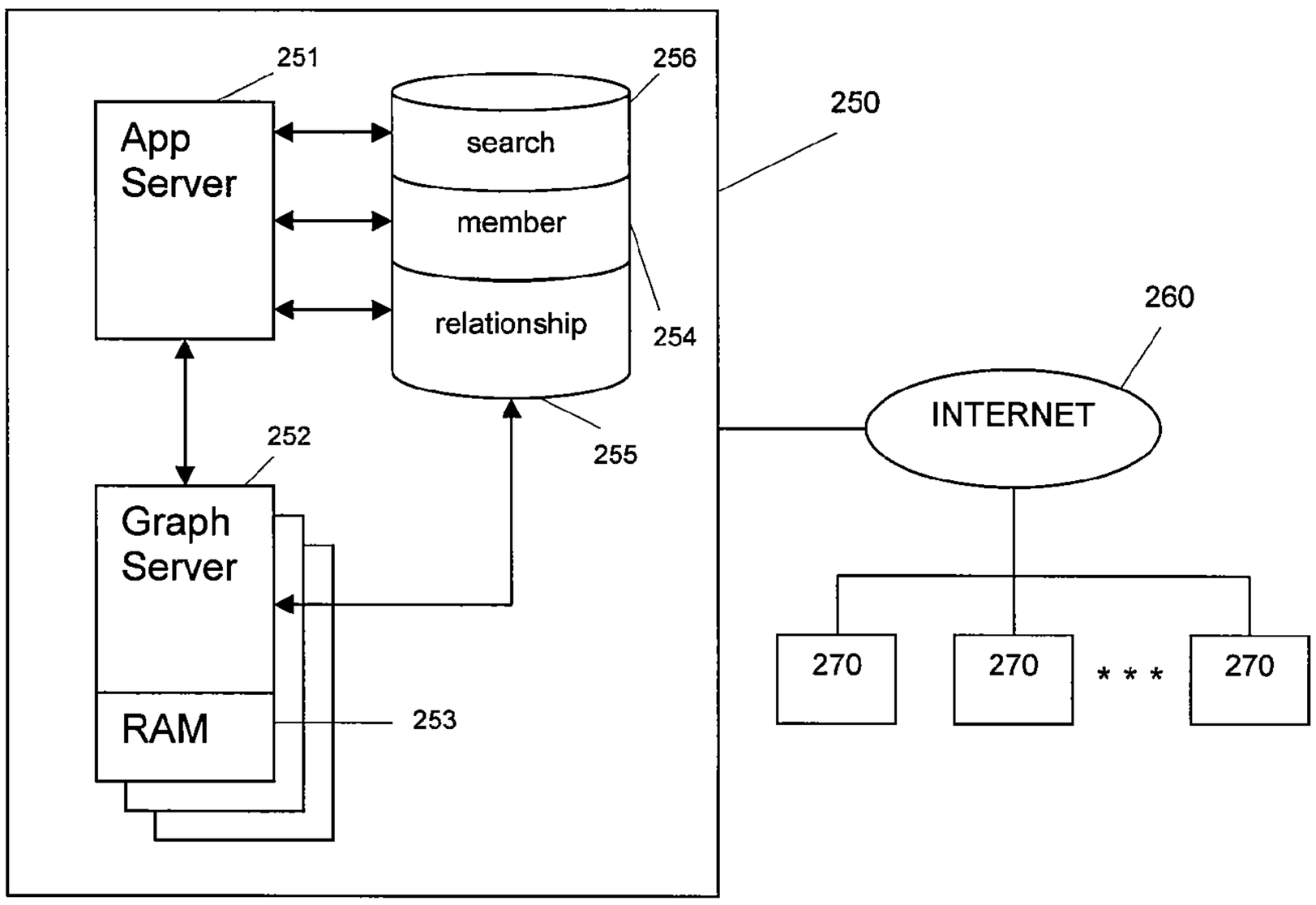
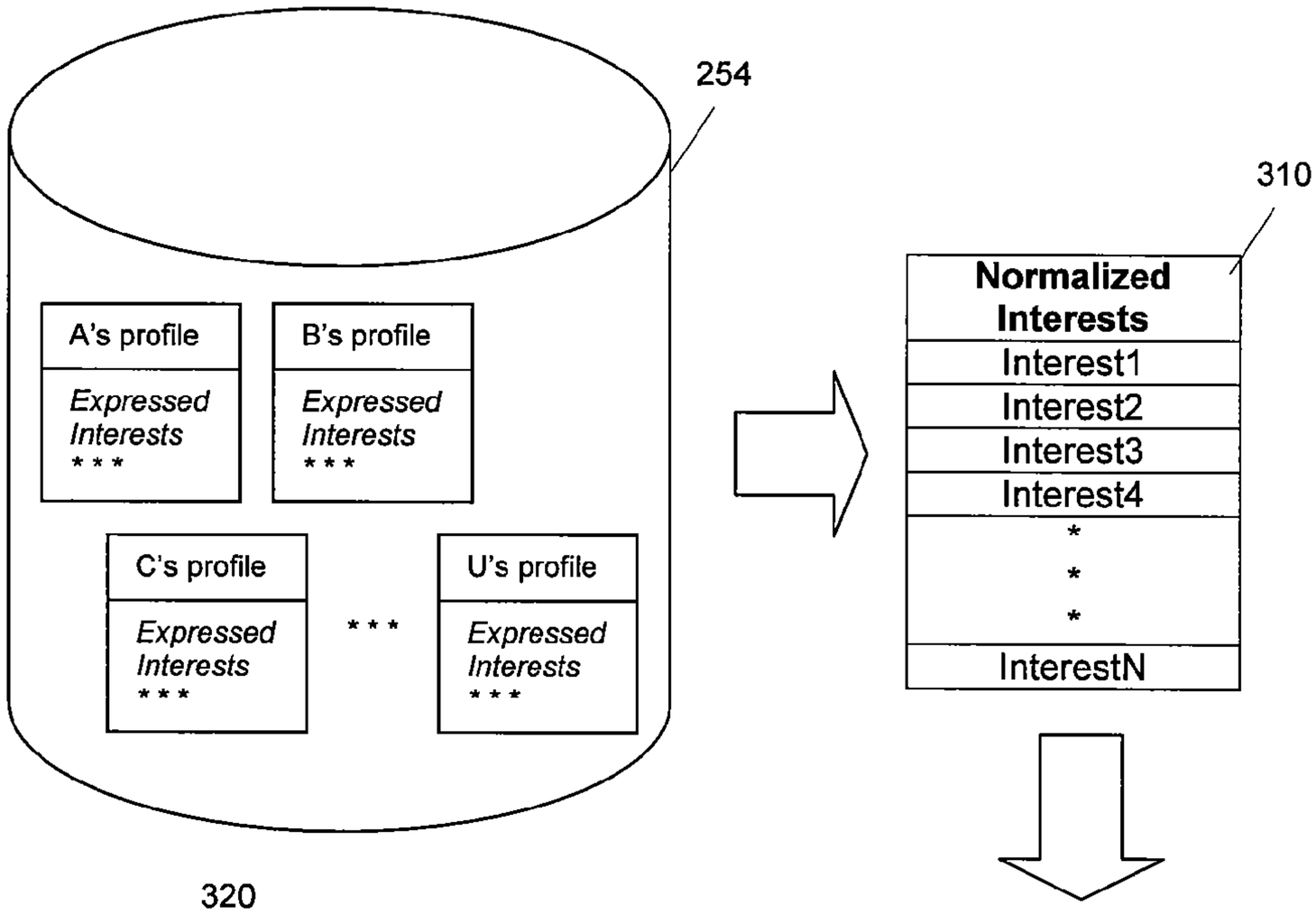

251
256
250
App Server
search
member
relationship
254
260
INTERNET
255
252
Graph Server
RAM
253
270
270
* * *
270

FIG. 3



	Interest1	Interest2	Interest3	* * *	InterestN
Interest1					
Interest2					
Interest3					
* * *					
InterestN					

FIG. 4

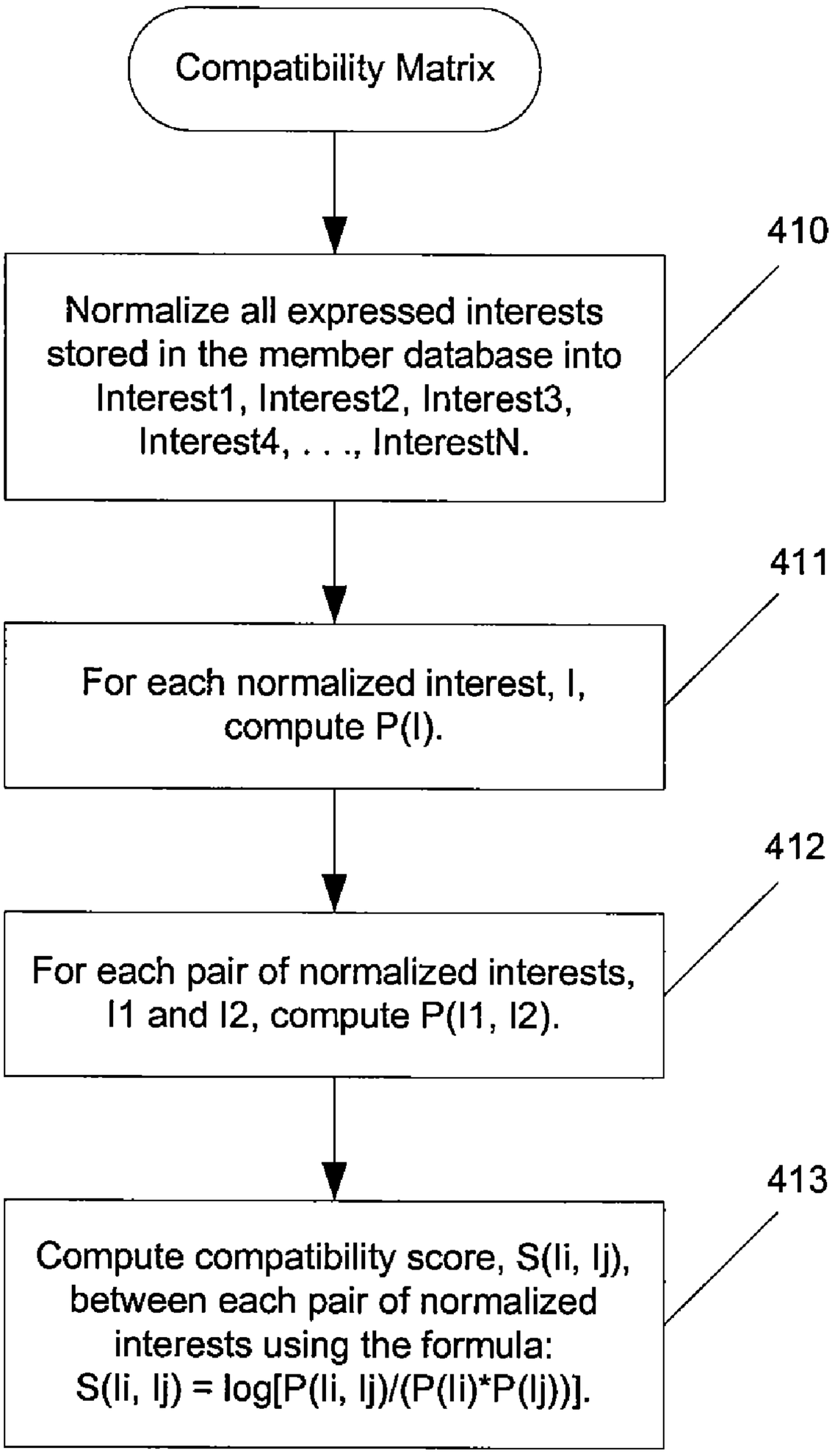

Compatibility Matrix
410
Normalize all expressed interests stored in the member database into Interest1, Interest2, Interest3, Interest4, . . ., InterestN.
411
For each normalized interest, I, compute P(I).
412
For each pair of normalized interests, I1 and I2, compute P(I1, I2).
413
Compute compatibility score, S(Ii, Ij), between each pair of normalized interests using the formula: S(Ii, Ij) = log[P(Ii, Ij)/(P(Ii)*P(Ij))].

FIG. 5

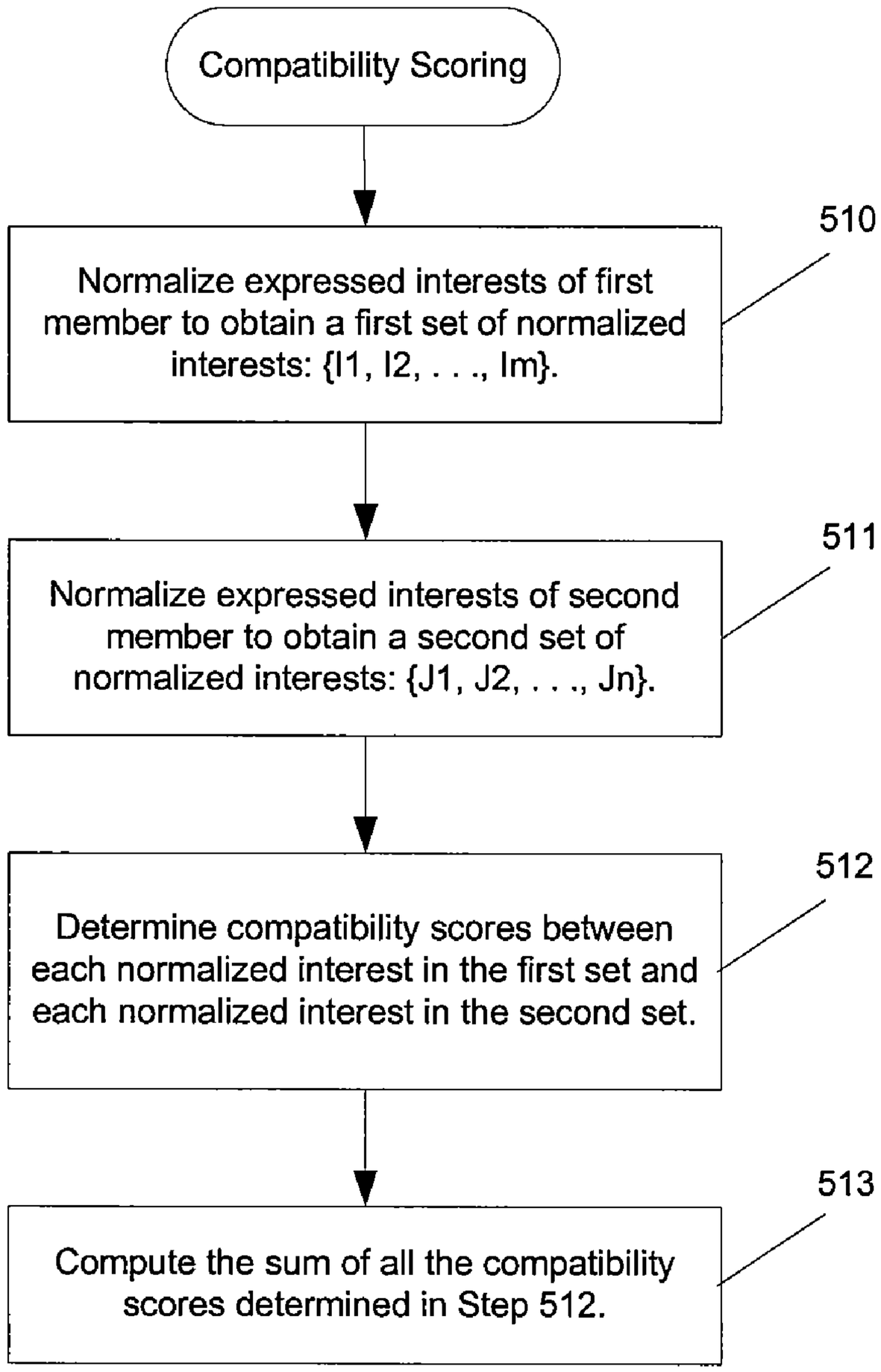

Compatibility Scoring
Normalize expressed interests of first member to obtain a first set of normalized interests: {I1, I2, . . ., Im}.
510
Normalize expressed interests of second member to obtain a second set of normalized interests: {J1, J2, . . ., Jn}.
511
Determine compatibility scores between each normalized interest in the first set and each normalized interest in the second set.
512
Compute the sum of all the compatibility scores determined in Step 512.
513

FIG. 6

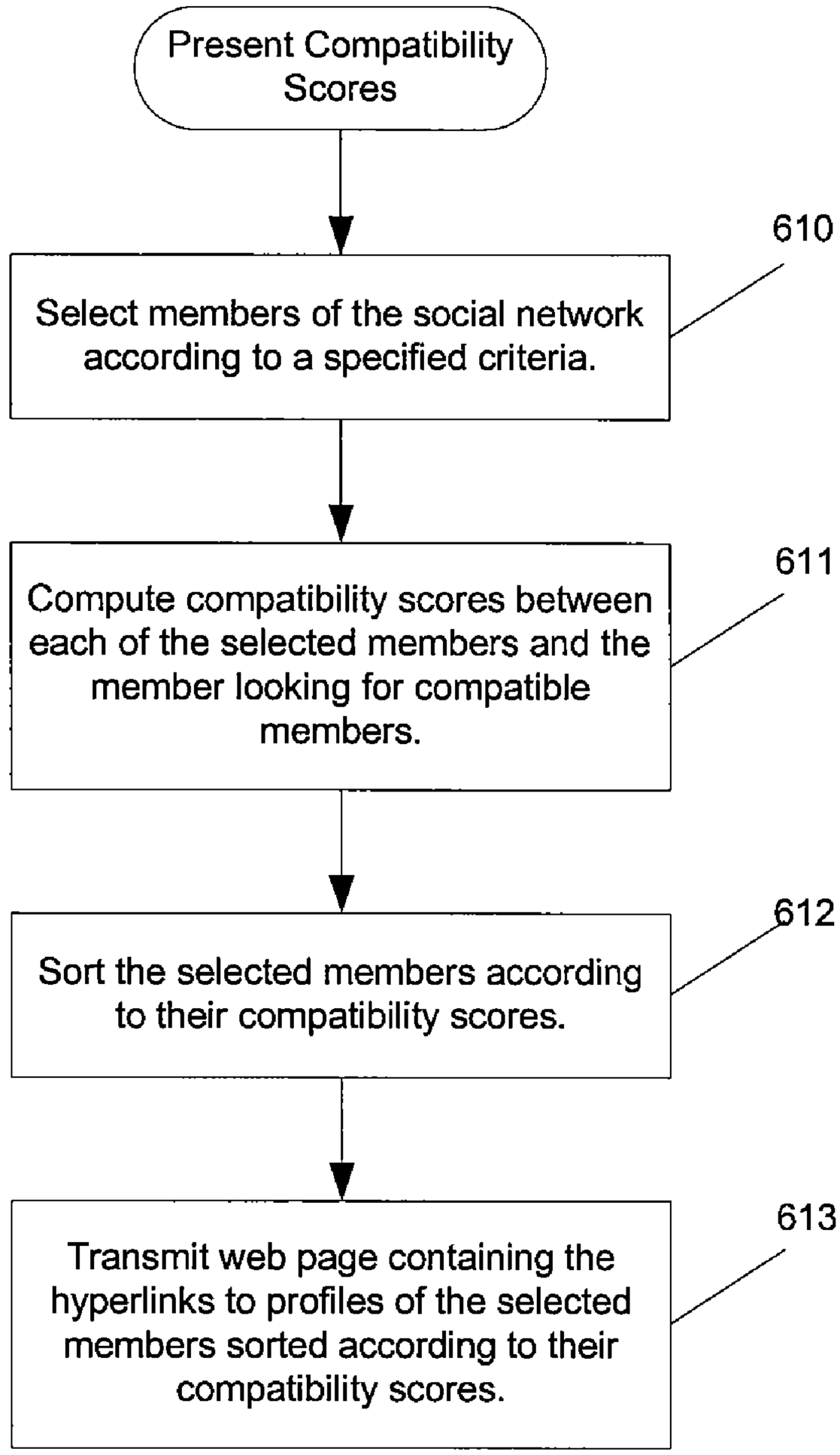

Present Compatibility Scores
610
Select members of the social network according to a specified criteria.
611
Compute compatibility scores between each of the selected members and the member looking for compatible members.
612
Sort the selected members according to their compatibility scores.
613
Transmit web page containing the hyperlinks to profiles of the selected members sorted according to their compatibility scores.

FIG. 7

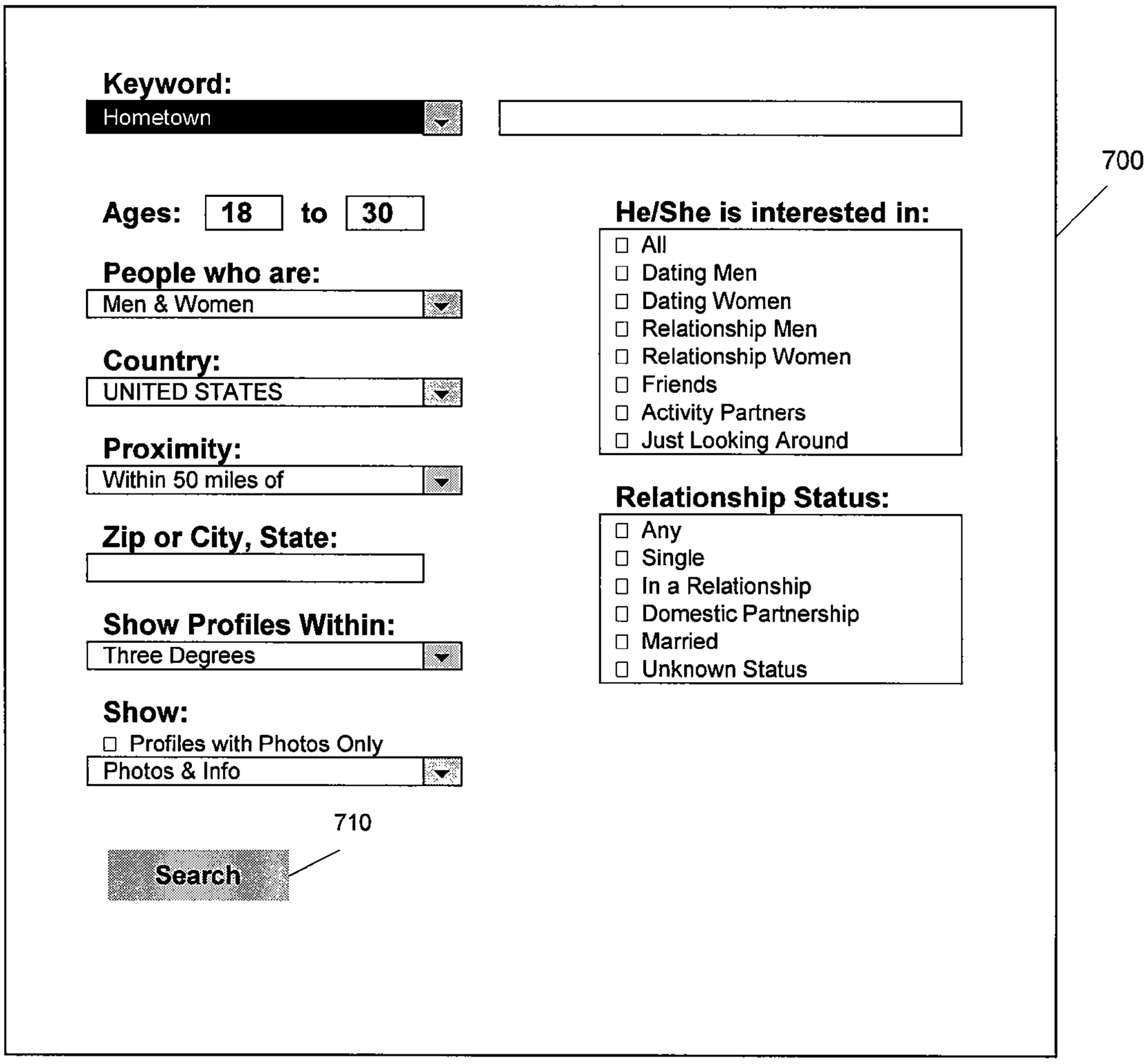

Keyword:
Hometown
700
Ages: 18 to 30
People who are:
Men & Women
Country:
UNITED STATES
Proximity:
Within 50 miles of
Zip or City, State:
Show Profiles Within:
Three Degrees
Show:
Profiles with Photos Only
Photos & Info
He/She is interested in:
All
Dating Men
Dating Women
Relationship Men
Relationship Women
Friends
Activity Partners
Just Looking Around
Relationship Status:
Any
Single
In a Relationship
Domestic Partnership
Married
Unknown Status
710
Search

FIG. 8

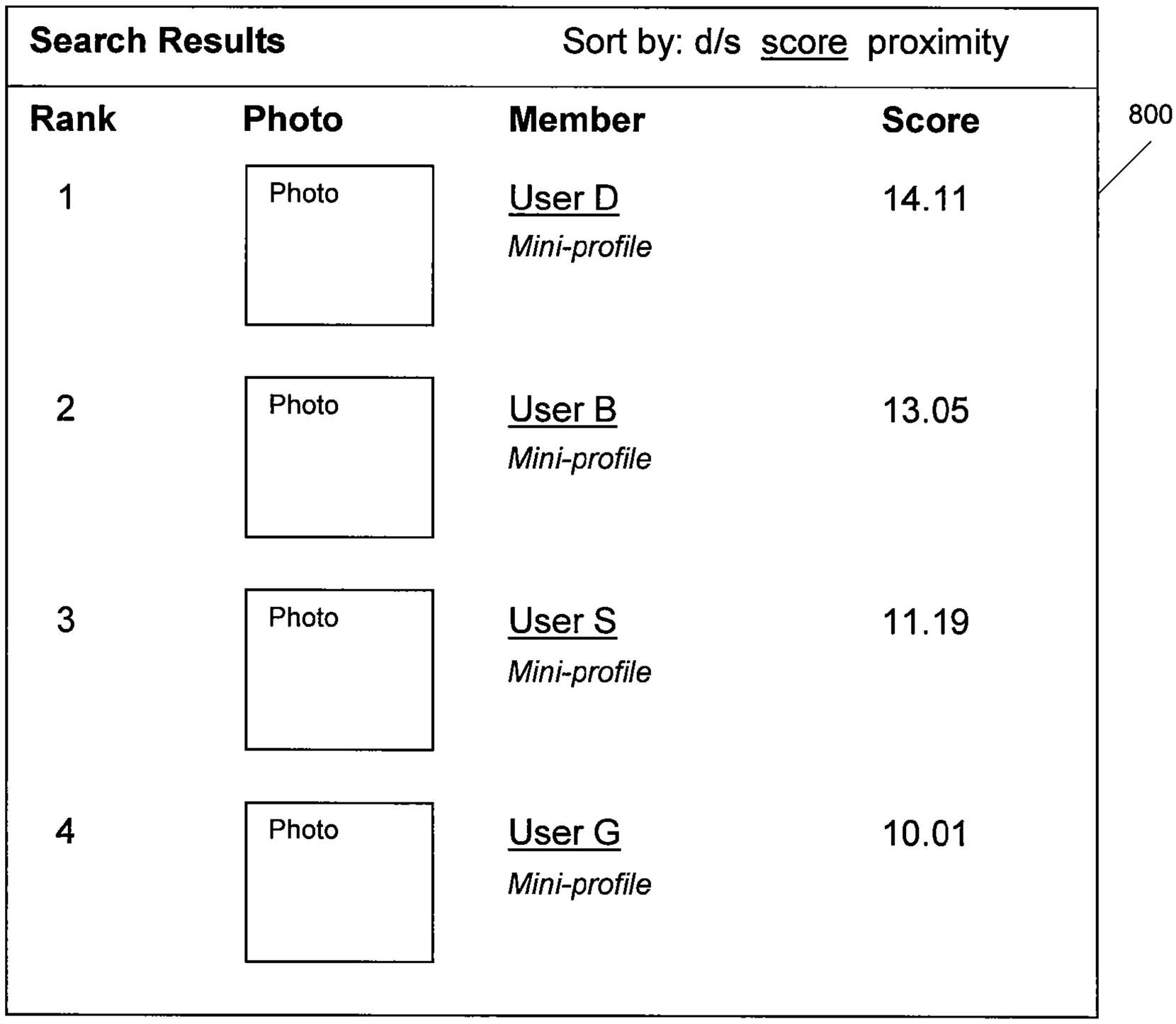
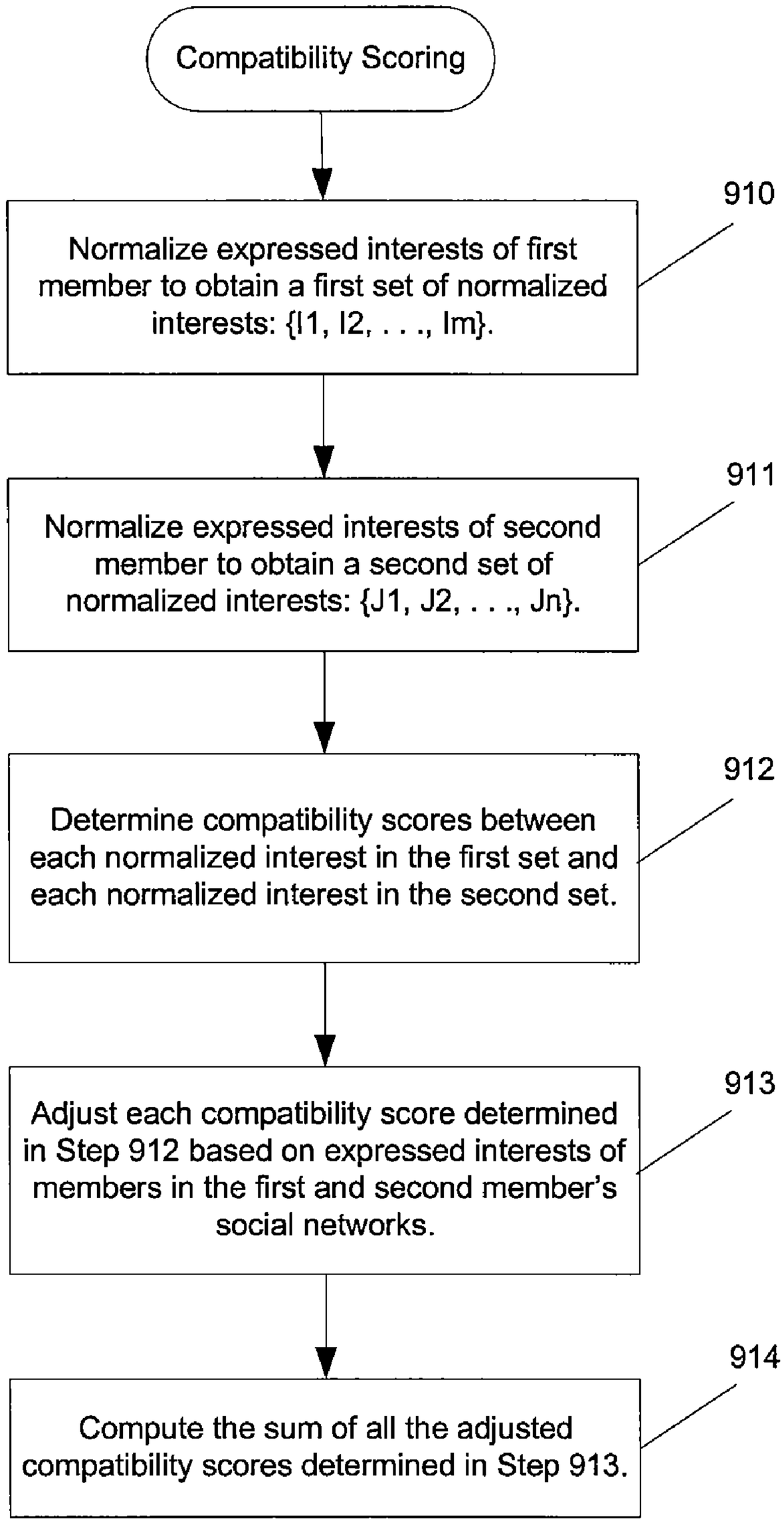

Search Results
Sort by: d/s score proximity
Rank
Photo
Member
Score
800
1
Photo
User D
Mini-profile
14.11
2
Photo
User B
Mini-profile
13.05
3
Photo
User S
Mini-profile
11.19
4
Photo
User G
Mini-profile
10.01

FIG. 9


Compatibility Scoring
Normalize expressed interests of first member to obtain a first set of normalized interests: {I1, I2, . . ., Im}.
910
Normalize expressed interests of second member to obtain a second set of normalized interests: {J1, J2, . . ., Jn}.
911
Determine compatibility scores between each normalized interest in the first set and each normalized interest in the second set.
912
Adjust each compatibility score determined in Step 912 based on expressed interests of members in the first and second member's social networks.
913
Compute the sum of all the adjusted compatibility scores determined in Step 913.
914

COMPATIBILITY SCORING OF USERS IN A SOCIAL NETWORK

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a divisional of U.S. patent application Ser. No. 11/117,793, filed on Apr. 28, 2005 now U.S. Pat. No. 7,451,161.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention generally relates to processing of social network data, and more particularly, to a method for scoring compatibility between members of an online social network.

2. Description of the Related Art

Several online dating and friend-making sites currently operate on the Internet. These services are generally similar in function. They allow users to post profiles and photos, as well as search through the profiles and photos of other users. Communication between users is provided anonymously, since users are identified by pseudonyms.

Initially, these sites implemented rudimentary techniques to match users. These techniques amounted to no more than user profile searches based on criteria such as age, gender, location, and physical characteristics. More recently, these sites have implemented more sophisticated processes in an effort to find better matches for their users. These processes attempt to assess an individual's personality based on specially designed tests or questionnaires and find users who have compatible personalities.

SUMMARY OF THE INVENTION

The present invention bases compatibility of two individuals who are members of a social network on the compatibility of interests expressed by these individuals, and provides for methods for quantifying compatibility of interests, scoring compatibility of the two individuals in accordance with compatibility of interests expressed by these individuals, and presenting compatibility results that include the compatibility scores.

The method of quantifying compatibility of interests includes the steps of calculating an estimated probability associated with each interest (referred to herein as "interest probability") and each pair of interests (referred to herein as "joint probability"), and assigning an interest compatibility score between each pair of interests based on the estimated probabilities. The estimated interest probability for a particular interest represents the probability that a member of the social network will express that interest as one of his or her interests. The estimated joint probability for a particular pair of interests represents the probability that a member of the social network will express both interests in the pair as his or her interests.

In accordance with one embodiment of the present invention, the interest compatibility score between each pair of interests is computed as a function of the estimated joint probability for the pair, and the estimated interest probabilities for the first and second interests of the pair.

The method of scoring compatibility in accordance with compatibility of interests includes the steps of preparing interest compatibility scores based on expressed interests of the members of the social network, and computing a compatibility score between a first member of the social network and a second member of the social network based on expressed interests of the first member, expressed interests of the second member, and the interest compatibility scores between the expressed interests of the first member and the expressed interests of the second member. The interest compatibility score for any two expressed interests represents the degree of compatibility between the two expressed interests.

The method of presenting compatibility results that include the compatibility scores, e.g., to an individual in the social network, includes the steps of preparing interest compatibility scores based on expressed interests of the individuals in the social network, selecting a set of individuals who are within a predetermined degree of separation from the first individual, and computing a compatibility score between the first individual and each of the individuals in the set. If the predetermined degree of separation is set as one, this means that only the compatibility scores of the first individual's direct friends will be presented. The compatibility results that include the compatibility scores are presented as a web page and before the web page is transmitted to be displayed, the compatibility results are sorted in the order of the compatibility scores. By providing compatibility scores and linking it to interest profiles, the invention encourages people to enter interests so the site can find other people who share the same or compatible interests.

BRIEF DESCRIPTION OF THE DRAWINGS

So that the manner in which the above recited features of the present invention can be understood in detail, a more particular description of the invention, briefly summarized above, may be had by reference to embodiments, some of which are illustrated in the appended drawings. It is to be noted, however, that the appended drawings illustrate only typical embodiments of this invention and are therefore not to be considered limiting of its scope, for the invention may admit to other equally effective embodiments.

FIG. **1** is a diagram that graphically represents the relationships between members in a social network;

FIG. **2** is a block diagram illustrating components of a system for managing an online social network;

FIG. **3** schematically illustrates the process for computing interest compatibility data from a member database containing interest data;

FIG. **4** is a flow diagram illustrating the process steps for computing interest compatibility data from a member database containing interest data;

FIG. **5** is a flow diagram illustrating the process steps for computing a compatibility score between two members of a social network according to an embodiment of the present invention;

FIG. **6** is a flow diagram illustrating the process steps for generating a member search results page containing compatibility scores;

FIG. **7** is a sample GUI used to specify member search criteria;

FIG. **8** is a sample member search results page containing compatibility scores; and

FIG. **9** is a flow diagram illustrating the process steps for computing a compatibility score between two members of a social network according to another embodiment of the present invention.

DETAILED DESCRIPTION

FIG. **1** is a graph representation of a social network centered on a given individual (ME). Other members of this

social network include A-U whose position, relative to ME's, is referred to by the degree of separation between ME and each other member. Friends of ME, which includes A, B, and C, are separated from ME by one degree of separation (1 d/s). A friend of a friend of ME is separated from ME by 2 d/s. As shown, D, E, F, G, and H are each separated from ME by 2 d/s. A friend of a friend of a friend of ME is separated from ME by 3 d/s. FIG. **1** depicts all nodes separated from ME by more than 3 degrees of separation as belonging to the category ALL.

Degrees of separation in a social network are defined relative to an individual. For example, in ME's social network, H and ME are separated by 2 d/s, whereas in G's social network, H and G are separated by only 1 d/s. Accordingly, each individual will have their own set of first, second and third degree relationships.

As those skilled in the art understand, an individual's social network may be extended to include nodes to an Nth degree of separation. As the number of degrees increases beyond three, however, the number of nodes typically grows at an explosive rate and quickly begins to mirror the ALL set.

FIG. **2** is a block diagram illustrating a system for creating and managing an online social network. As shown, FIG. **2** illustrates a system **250** that includes an application server **251** and one or more graph servers **252**. The system **250** is connected to a network **260**, e.g., the Internet, and accessible over the network by a plurality of computers, collectively designated as **270**. The application server **250** manages a member database **254**, a relationship database **255**, and a search database **256**. The member database **254** contains profile information for each of the members in the online social network managed by the system **250**. The profile information may include, among other things: a unique member identifier, name, age, gender, location, hometown, references to image files, listing of interests, attributes, and the like. The relationship database **255** stores information defining to the first degree relationships between members. In addition, the contents of the member database **254** are indexed and optimized for search, and stored in the search database **256**. The member database **254**, the relationship database **255**, and the search database **256** are updated to reflect inputs of new member information and edits of existing member information that are made through the computers **270**.

The application server **250** also manages the information exchange requests that it receives from the remote computers **270**. The graph servers **252** receive a query from the application server **251**, process the query and return the query results to the application server **252**. The graph servers **252** manage a representation of the social network for all the members in the member database. The graph servers **252** have a dedicated memory device **253**, such as a random access memory (RAM), in which an adjacency list that indicates all first degree relationships in the social network is stored. The graph servers **252** respond to requests from application server **251** to identify relationships and the degree of separation between members of the online social network.

FIG. **3** illustrates the member database **254** in additional detail and shows that the interest data stored therein is first converted into a set **310** of normalized interests and then to a matrix **320** of interest compatibility scores. The conversion into normalized interests and then to interest compatibility scores is performed by a processing unit of the application server **251**.

The interest normalization process is in essence an interest classification process. It is performed so that the same interest expressed in different ways will be classified under that same interest. For example, an interest expressed as reading may be classified under the same normalized interest as an interest expressed as books. In the set **310** of normalized interests shown in FIG. **3**, the normalized interests are shown as a list. In an alternative embodiment, the normalized interests may be arranged as a hierarchical tree. Further, the present invention may be applied to systems where members input interests by selecting one or more interests that have been pre-defined by the system operator. In such a case, the normalization step is not performed and the set of pre-defined interests is used as the set **310** of normalized interests.

The matrix **320** of interest compatibility scores provides numerical scores that represent how compatible each pair of normalized interests, Interest**1**, Interest**2**, . . . , InterestN, is. Each off-diagonal cell in the matrix **320** has a numerical score entry that indicates the compatibility of the two interests associated with that cell's row and column. Each diagonal cell in the matrix **320** has a numerical score entry that is a measure of the rarity of the interests associated with that cell's row and column. A rare interest has a high score. A commonly occurring interest has a low score. In the embodiment of the present invention illustrated herein, the interest compatibility scores are compiled automatically based on the expressed interests of the members that have been normalized. The interest compatibility scores can also be manually created or they can be created using a combination of automatic and manual processes. Further, any of the interest compatibility scores that are compiled automatically may be manually adjusted.

FIG. **4** is a flow diagram that illustrates the process steps involved in generating the matrix **320**. In Step **410**, all expressed interests stored in the member database **254** are normalized into the set **310** of normalized interests, Interest**1**, Interest**2**, InterestN. A standard data mining methodology known as clustering can be used in Step **410**. For each normalized interest, I, the probability, P(I), is calculated (Step **411**). P(I) represents the probability that a member will express an interest that corresponds to the normalized interest, I, and is calculated using the expressed interests stored in the member database **254** according to the formula: P(I)= (number of times an interest corresponding to the normalized interest, I, is expressed in the member database **254**)/(total number of expressed interests in the member database **254**). For each pair of normalized interests, I**1** and I**2**, the probability, P(I**1**, I**2**), is calculated (Step **412**). P(I**1**, I**2**) represents the probability that a member will express interests that correspond to the normalized interests, I**1** and I**2**, and is calculated using the expressed interests stored in the member database **254** according to the formula: P(I**1**, I**2**)=(number of members who expressed interests corresponding to both of the normalized interests, I**1** and I**2**, in the member database **254**)/(total number of expressed interests in the member database **254**). In cases where I**1**=I**2**, P(I**1**, I**2**) is set to P(I**1**) or P(I**2**). In Step **413**, an interest compatibility score, S(Ii, Ij), is calculated between each pair of normalized interests using the formula: S(Ii, Ij)=log[P(Ii, Ij)/(P(Ii)*P(Ij))]. Because of the division by [P(Ii)*P(Ij)], using this formula, the commonality of rare interests are rated higher than commonality in more popular interests.

FIG. **5** is a flow diagram that illustrates the process steps executed by the processor of the application server **251** in computing a compatibility score between two members, e.g., a first member and a second member. In Step **510**, the expressed interests of the first member are normalized into a first set {I**1**, I**2**, . . . , Im} of normalized interests, where m represents the number of normalized interests in the first set. In Step **511**, the expressed interests of the second member are normalized into a second set {J**1**, J**2**, . . . , Jn} of normalized

interests, where n represents the number of normalized interests in the second set. In Step **512**, the interest compatibility scores for all pairs of normalized interests in the first and second sets are determined from the matrix **320**. For example, if the first set is {Interest_**1**, Interest_**2**} and the second set is {Interest_**2**, Interest_**3**}, the following compatibility scores are retrieved from the matrix **320**:
Compatibility(Interest_**1**, Interest_**2**);
Compatibility(Interest_**1**, Interest_**3**);
Compatibility(Interest_**2**, Interest_**2**); and
Compatibility(Interest_**2**, Interest_**3**).

In Step **513**, the compatibility scores determined in Step **512** are summed, and the sum represents the compatibility score between the first member and the second member.

FIG. **6** is a flow diagram that illustrates the process steps executed by the processor of the application server **251** in presenting compatible scores of those members who meet a set of criteria specified by a member of the social network. In Step **610**, the members of the social network who meet the specified criteria are selected. A sample graphical user interface (GUI) for specifying the set of criteria is illustrated in FIG. **7**. The GUI **700** shows the criteria that can be specified by the member. They include: age, gender (men, women, men & women), location, purpose of the search, relationship status and keywords in selected categories such as hometown, companies, schools, affiliations, interests, favorite movies, favorite books, favorite music, and favorite TV shows. The GUI **700** also provides a setting for degree of separation (d/s): members who are within 1 d/s, members who are within 2 d/s, members who are within 3 d/s, or all members. After specifying the criteria, the member clicks on the search button **710**, in response to which the application server **251** performs the search of the members who meet the specified criteria.

In Step **611**, a compatibility score between the member specifying the criteria and each member of the social network who meets the specified search criteria is computed. In Step **612**, the members of the social network who meet the specified search criteria are sorted according to their compatibility scores, and in Step **613**, a web page containing images, mini-profiles, and hyperlinks associated with the members of the social network who meet the specified search criteria are transmitted to the member for display. The web page transmitted in Step **613** is formatted such that the images, mini-profiles, and hyperlinks associated with the members are displayed according their compatibility scores (highest to lowest). FIG. **8** shows a sample search results page **800**.

The compatibility score between two members can be adjusted based on relationship information stored for the two members. In one embodiment, the compatibility score between the two members is increased based on the number of common first through Nth degree friends that the members have. N is typically set to 2 or 3, but may be any positive integer. The compatibility score may be increased in proportion to the number of common first through Nth degree friends that the members have, with the increase based on first degree friends being weighted higher than the increase based on second degree friends, and the increase based on second degree friends being weighted higher than the increase based on third degree friends, and so forth.

In another embodiment, the compatibility score between a first member of the social network and a second member of the social network is adjusted based on the commonality of the first member's expressed interest in the first member's social network and the commonality of the second member's expressed interest in the second member's social network. FIG. **9** is a flow diagram that illustrates the process steps executed by the processor of the application server **251** in computing a compatibility score between two members, e.g., a first member and a second member, with the adjustment based on the commonality of the first member's expressed interest in the first member's social network and the commonality of the second member's expressed interest in the second member's social network.

In Step **910**, the expressed interests of the first member are normalized into a first set {I**1**, I**2**, . . . , Im} of normalized interests, where m represents the number of normalized interests in the first set. In Step **911**, the expressed interests of the second member are normalized into a second set {J**1**, J**2**, . . . , Jn} of normalized interests, where n represents the number of normalized interests in the second set. In Step **912**, the interest compatibility scores for all pairs of normalized interests in the first and second sets are determined from the matrix **320**. For example, if the first set is {Interest_**1**, Interest_**2**} and the second set is {Interest_**2**, Interest_**3**}, the following compatibility scores are retrieved from the matrix **320**:
Compatibility(Interest_**1**, Interest_**2**);
Compatibility(Interest_**1**, Interest_**3**);
Compatibility(Interest_**2**, Interest_**2**); and
Compatibility(Interest_**2**, Interest_**3**).

In Step **913**, each of the compatibility scores determined in Step **912** is adjusted based on the commonality of the first member's expressed interest in the first member's social network and the commonality of the second member's expressed interest in the second member's social network. For example, the adjustments, k**12**, k**13**, k**22**, k**23**, are made to the compatibility scores determined in Step **912** as follows:
k**12***Compatibility(Interest_**1**, Interest_**2**);
k**13***Compatibility(Interest_**1**, Interest_**3**);
k**22***Compatibility(Interest_**2**, Interest_**2**); and
k**23***Compatibility(Interest_**2**, Interest_**3**).

The adjustment, kij, is a function of the number of first through Nth degree friends of the first member who have expressed an interest corresponding to Interest_i and the number of first through Nth degree friends of the second member who have expressed an interest corresponding to Interest_j. N is typically set to 3 or 4, but may be any positive integer. The properties of the adjustment, kij, are as follows:

1. kij≧1;
2. kij=kji;
3. kij increases in proportion to the number of friends of the first member who have expressed an interest corresponding to Interest_i, with the amount of increase being weighted higher for closer degree friends; and
4. kij increases in proportion to the number of friends of the second member who have expressed an interest corresponding to Interest_j, with the amount of increase being weighted higher for closer degree friends.

In Step **914**, the adjusted compatibility scores determined in Step **913** are summed, and the sum represents the compatibility score between the first member and the second member.

While particular embodiments according to the invention have been illustrated and described above, those skilled in the art understand that the invention can take a variety of forms and embodiments within the scope of the appended claims.

What is claimed is:

1. A method of quantifying compatibilities between interests using multiple sets of interest data stored in a database, comprising the steps of:

for each interest, calculating, using one or more computer processors, an estimated probability pertaining to said interest;

for each pair of interests, calculating, using the one or more computer processors, an estimated probability pertaining to said pair of interests; and

assigning an interest compatibility score between each pair of interests, wherein the interest compatibility score between each pair of interests is a function of the estimated probability calculated for said pair of interests divided by the product of the estimated probability calculated for a first interest of said pair of interests and the estimated probability calculated for a second interest of said pair of interests.

2. The method according to claim **1**, wherein the estimated probability pertaining to an interest is equal to a probability that said interest will appear as an interest in a set of interest data stored in the database.

3. The method according to claim **2**, wherein the estimated probability pertaining to a pair of interests is equal to a probability that said pair of interests will appear together as interests in a set of interest data stored in the database.

4. The method according to claim **1**, wherein the database maintains interest data for a plurality of users, and each set of interest data relates to interests expressed by one of the users.

5. The method according to claim **4**, further comprising the step of normalizing the interests expressed by the users prior to the steps of calculating and assigning.

6. The method according to claim **5**, wherein a clustering technique is used during the step of normalizing.

7. The method according to claim **6**, wherein the interest compatibility score provides a numerical score that represents the compatibility of the pair of interests.

8. The method according to claim **1**, wherein the interest compatibility score provides a numerical score that represents the compatibility of the pair of interests.

9. The method according to claim **8**, wherein a commonly occurring pair of interests has a low interest compatibility score.

10. The method according to claim **8**, wherein a rarely occurring pair of interests has a high interest compatibility score.

11. A system for quantifying compatibilities between interests, comprising:

a database storing multiple sets of interest data, wherein each set of interest data includes interests of members of an online social network; and

an application server configured to:

for each interest, calculate an estimated probability pertaining to said interest;

for each pair of interests, calculate an estimated probability pertaining to said pair of interests; and

assign an interest compatibility score between each pair of interests, wherein the interest compatibility score between each pair of interests is a function of the estimated probability calculated for said pair of interests divided by the product of the estimated probability calculated for a first interest of said pair of interests and the estimated probability calculated for a second interest of said pair of interests.

12. The system according to claim **11**, wherein the estimated probability pertaining to an interest is equal to a probability that said interest will appear as an interest in a set of interest data stored in the database.

13. The system according to claim **12**, wherein the estimated probability pertaining to a pair of interests is equal to a probability that said pair of interests will appear together as interests in a set of interest data stored in the database.

14. The system according to claim **11**, wherein the database maintains interest data for a plurality of members of the online social network, and each set of interest data relates to interests expressed by one of the members.

15. The system according to claim **14**, wherein the application server is further configured to normalize the interests expressed by the users prior to the steps of calculating and assigning.

16. The system according to claim **15**, wherein a clustering technique is used in normalizing the interests.

17. The system according to claim **16**, wherein the interest compatibility score provides a numerical score that represents the compatibility of the pair of interests.

18. The system according to claim **11**, wherein the interest compatibility score provides a numerical score that represents the compatibility of the pair of interests.

19. The system according to claim **18**, wherein a commonly occurring pair of interests has a low interest compatibility score.

20. The system according to claim **18**, wherein a rarely occurring pair of interests has a high interest compatibility score.

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